

**NOVEL METHOD FOR PREPARING STYRYL PYRAZOLE, ISOXAZOLE
AND ISOTHIAZOLE DERIVATIVES**

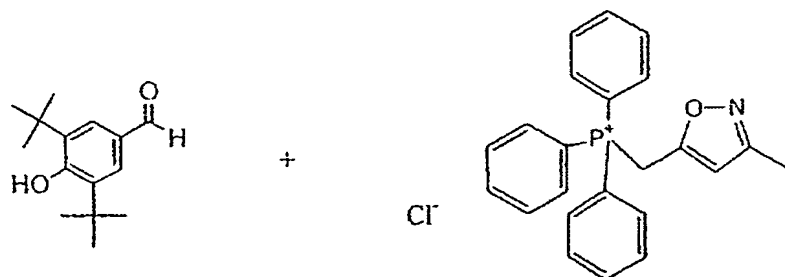
The present invention relates to a novel method
5 for synthesizing styryl isoxazole, styryl pyrazole and
styryl isothiazole derivatives.

The subject of the present invention is in
particular a method for producing compounds of the
styryl isoxazole, styryl pyrazole and styryl
10 isothiazole family in a synthesis step followed by
recrystallization from a basic alcoholic medium,
serving as a dehydration and a purification. This
method relates in particular to the production of
(E)-5-[2-(3,5-di-tert-butyl-4-hydroxyphenyl)vinyl]-3-
15 methylisoxazole also called 5-[β -(4'-hydroxy-3',5'-bis-
(1,1-dimethylethyl)phenyl)ethenyl]-3-methylisoxazole.

Styryl isoxazole, styryl pyrazole and styryl
isothiazole compounds, and in particular (E)-5-[2-(3,5-
di-tert-butyl-4-hydroxyphenyl)vinyl]-3-methylisoxazole,
20 have been described in patent EP 0 245 825. These
compounds, which are 5-lipoxygenase and cyclooxygenase
inhibitors, can be used in a pharmaceutical
composition. They also have sunscreen properties. In
particular, they are capable of entering into the
25 composition of pharmaceutical formulations for the
treatment of inflammation, arthritis, ulcers,
allergies, asthma, psoriasis, cardiovascular states in
mammals. They are also used in compositions for
protecting against ultraviolet light.

30 The synthesis of styryl isoxazole derivatives
which is described in patent EP 0 245 825 may be
carried out according to three approaches. In
particular, in the case of (E)-5-[2-(3,5-di-tert-butyl-
4-hydroxyphenyl)vinyl]-3-methylisoxazole, the following
35 three synthesis schemes are possible:

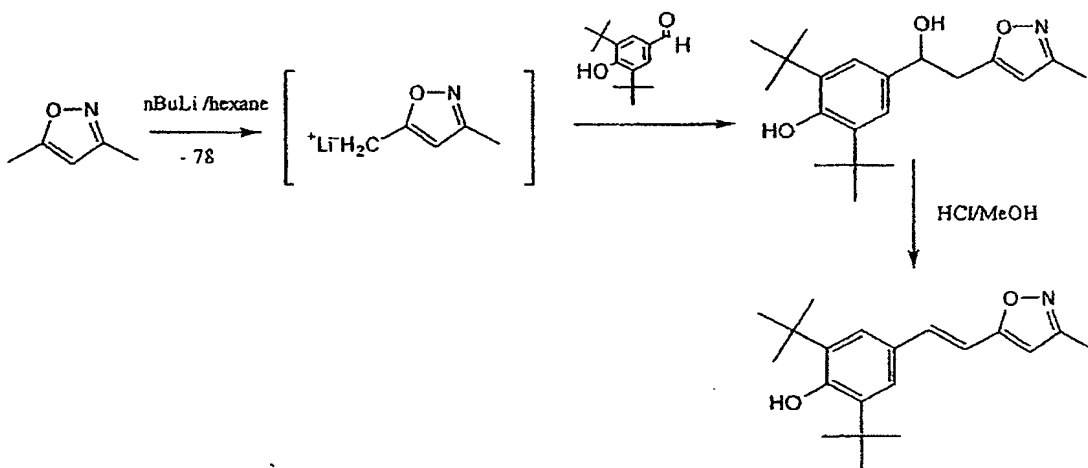
I Wittig reaction between the aldehyde
(3,5-di-tert-butyl-4-hydroxybenzaldehyde) and 3,5-di-
methylisoxazole triphenylphosphonium



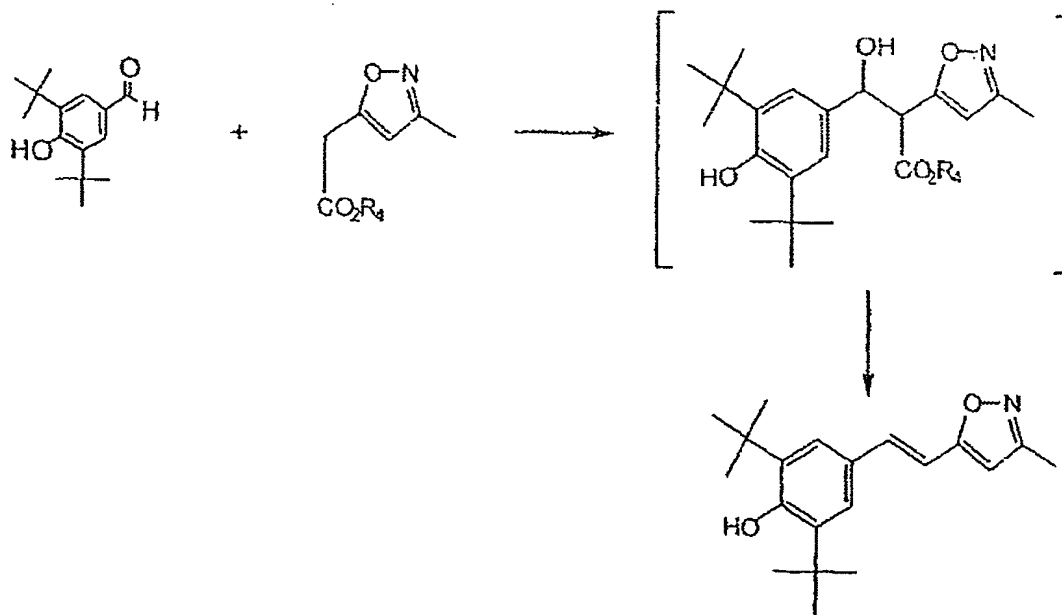
II Two-step method comprising:

- A reaction between the aldehyde (3,5-di-tert-butyl-4-hydroxybenzaldehyde) and the lithium salt of 3,5-dimethylisoxazole followed by chromatography on a silica gel column.

- A second step comprising the treatment of the product resulting from the first step with hydrochloric acid in methanol to give, after purification on a silica gel column, the desired compound with a yield of 49%.



III A third approach consists in reacting the aldehyde (3,5-di-tert-butyl-4-hydroxybenzaldehyde) with a 3-carboxylate derivative of isoxazole. After condensation, a dehydration and a decarboxylation are carried out.

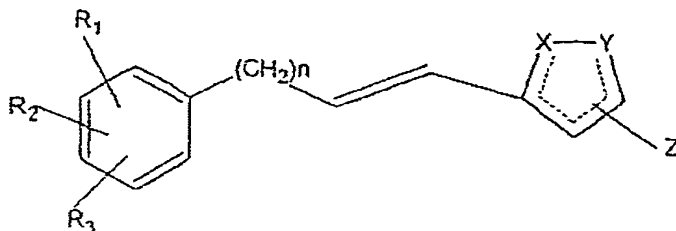


The same synthesis schemes make it possible to obtain the styryl pyrazole and styryl isothiazole derivatives.

5 While the prior art methods make it possible to obtain the styryl isoxazole, styryl pyrazole and styryl isothiazole derivatives, they have the disadvantage of requiring the use of several steps and/or of purifications by chromatography in order to obtain a
10 pure product.

The applicant set itself the objective of developing a method for preparing styryl isoxazole, styryl pyrazole and styryl isothiazole derivatives comprising a limited number of steps and making it
15 possible to obtain a product having satisfactory purity without the need to use complicated and/or expensive purification steps.

The method of synthesis according to the invention applies to the preparation of compounds
20 corresponding to formula (I) below



(I)

in which:

R_1 , R_2 , R_3 , at the 2, 3, 4, 5 or 6 position of the phenyl ring, which are identical or different, are chosen from: a hydrogen atom; C_1 - C_6 alkyls; C_2 - C_6 alkenyls; C_2 - C_6 alkynyls; halogens, C_1 - C_6 haloalkyls; -OH; the groups -OR', -SH, -SR', -SeH, -SeR', -C(O)R', -NHC(O)R', -C(S)R', -NHC(S)R', -CN in which R' represents a group chosen from C_1 - C_6 alkyls, C_2 - C_6 alkenyls, C_2 - C_6 alkynyls; the groups -C(O)OR'', -OC(O)R'', -NR''R''' in which R'' and R''', which are identical or different, represent a group chosen from a hydrogen atom, C_1 - C_6 alkyls, C_2 - C_6 alkenyls, C_2 - C_6 alkynyls;

X and Y represent a pair of atoms chosen from: (NR₄, N) (pyrazole ring), (O, N) (isoxazole ring), (S, N) (isothiazole ring), R₄ being chosen from: a hydrogen atom; C_1 - C_6 alkyls; the groups CH₂-OR₅, the groups C(O)OR₅ in which R₅ is chosen from a hydrogen atom, a C_1 - C_6 alkyl group, a benzyl group;

the heterocycle is linked to the phenyl ring via its 3- or 5- position in the case of the pyrazole ring, via its 5-position in the case of the isoxazole and isothiazole rings;

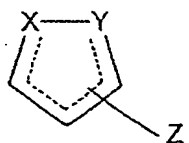
n represents an integer chosen from 0, 1, 2, 3, 4, 5 and 6;

Z, at the 3- or 4-position of the isoxazole, pyrazole or isothiazole ring, represents a group chosen from: a hydrogen atom; C_1 - C_6 alkyls; C_2 - C_6 alkenyls; C_2 - C_6 alkynyls; halogens, C_1 - C_6 haloalkyls; -OH; the groups -OR', -SH, -SR', -SeH, -SeR', -C(O)R', -NHC(O)R', -C(S)R', -NHC(S)R', -CN in which R'

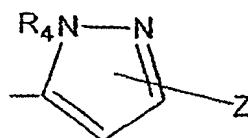
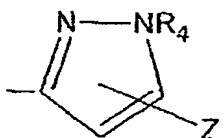
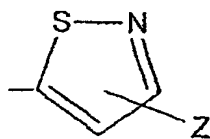
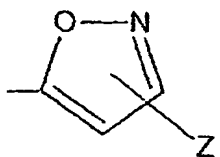
represents a group chosen from C₁-C₆ alkyls, C₂-C₆ alkenyls, C₂-C₆ alkynyls; the groups -C(O)OR'', -OC(O)R'', -NR''R''' in which R'' and R''', which are identical or different, represent a group chosen from a hydrogen atom, C₁-C₆ alkyls, C₂-C₆ alkenyls, C₂-C₆ alkynyls.

The terms alkyl, alkenyl and alkynyl used in the present invention designate either linear, branched or cyclic radicals.

The heterocycle represented by the formula below:



represents according to the invention a group chosen from:



Preferably, the method according to the present invention applies to the preparation of the products corresponding to formula (I) above, in which one or more of the conditions below are met:

R₁, R₂, R₃ are at the 3-, 4- or 5-position of the phenyl ring;

R₁, R₂, R₃ are chosen from: a hydrogen atom; C₁-C₆ alkyls; halogens; C₁-C₆ haloalkyls; -OH; the groups -OR', in which R' represents a group chosen from C₁-C₆ alkyls; the groups -OC(O)R'', in which R'' represents a group chosen from a hydrogen atom, C₁-C₆ alkyls;

X = O; Y = N;

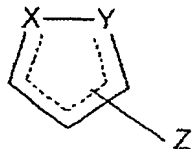
n = 0;

Z is at the 3-position of the heterocycle,

Z represents a group chosen from: C₁-C₆ alkyls;
5 halogens; C₁-C₆ haloalkyls.

Advantageously, at least one of the conditions
below is met:

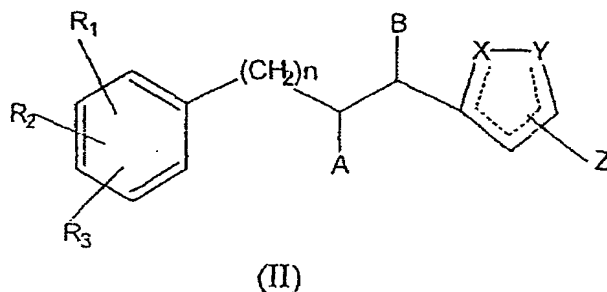
the heterocycle represented by formula:



10 is a Z-substituted derivative of 5-isoxazole;
R₁ at the 3-position is a tert-butyl group;
R₂ at the 4-position is a hydroxyl group;
R₃ at the 5-position is a tert-butyl group;
Z at the 3-position is a methyl group.

15 Still more preferably, the invention applies to
the preparation of (E)-5-[2-(3,5-di-tert-butyl-4-
hydroxyphenyl)vinyl]-3-methylisoxazole.

The method which is the subject of the present
invention is characterized in that it comprises at
20 least one step consisting in treating the product
corresponding to formula (II) below in which R₁, R₂, R₃,
X, Y, Z and n have the same definition as in formula
(I) above, in alcohol in the presence of a base to give
the product of formula (I):



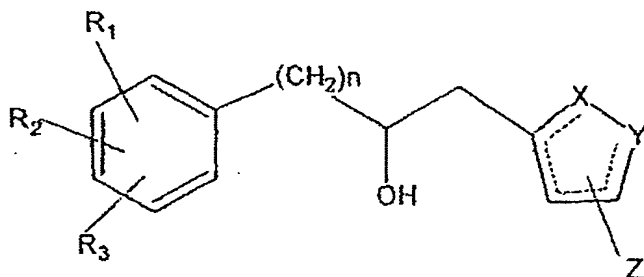
25 A and B being chosen such that one of A and B
is H, the other being -OH.

In the case of the derivatives of formula (I)

in which $n = 0$, the method is similar to that developed by Warnert Lambert in patent EP 0 245 825 in that it comprises the passage via a common intermediate, but it differs therefrom in the number of steps, the treatment and the purification. Indeed, the alcohol (II) is subjected to a treatment in a basic alcoholic medium with the double objective of: 1) dehydrating the hydroxyl (II), 2) crystallizing the product (I) and thereby removing the impurities in the mother liquors, which makes it possible to avoid a column chromatography. Recrystallization from an alcoholic medium can optionally complete this method in order to give the product (I).

Compared with the prior art methods, the method according to the invention is distinguishable by the following advantages: a better yield, a small number of steps, a better feasibility on an industrial scale.

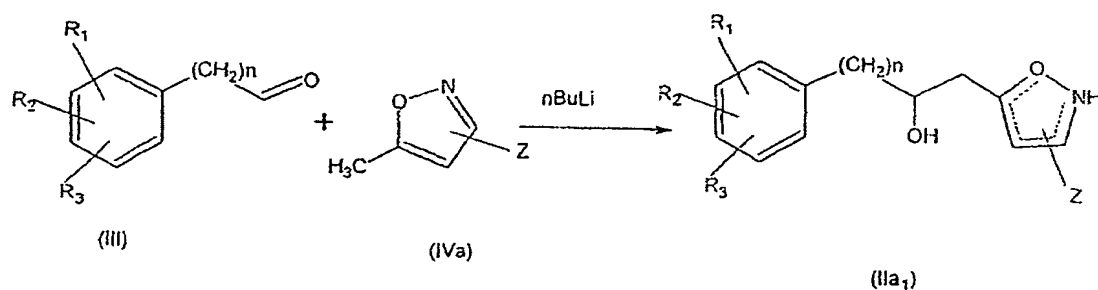
Preferably, the compound of formula (II) corresponds to formula (IIa) below in which R_1 , R_2 , R_3 , X, Y and Z have the same definition as in formula (I):



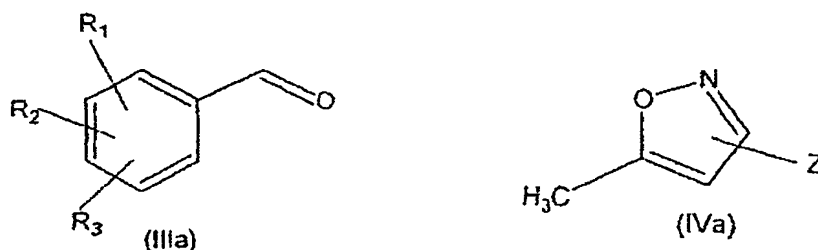
(IIa)

This variant represents the case where $A = OH$, $B = H$.

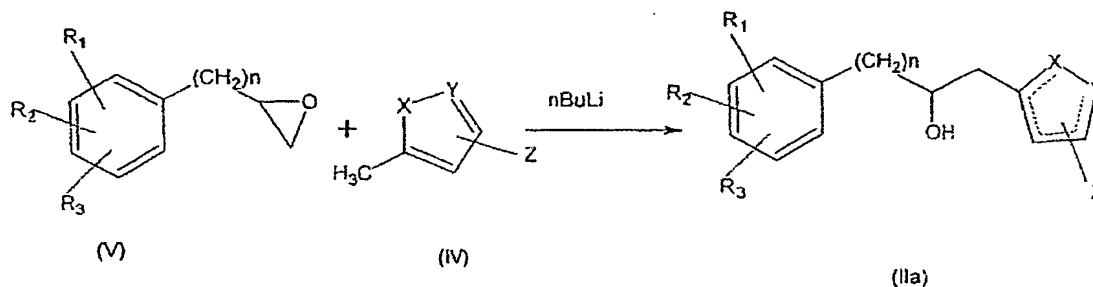
Advantageously, according to this variant of the invention, in the case where $X = O$ and $Y = N$, the compound of formula (IIa) is prepared by a method consisting in reacting the aldehyde (III) and the lithium salt of the heterocycle (IVa):



More particularly, in the case where $n = 0$, the compound of formula (II) is prepared by a method consisting in reacting the aldehyde (IIIa) and the
 5 lithium salt of the 5-methylisoxazole derivative (IVa):

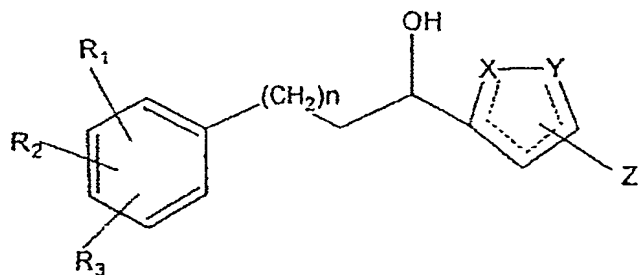


In the case where (X, Y) represents (S, N) or (NR_4, N) , R_4 having the same definition as above, it is possible to have the target molecules (IIa) by reacting
 10 the phenyloxirane derivatives (V) with the lithium salt of the 5-isothiazole derivative (compound (IV) with $X = S$ and $Y = N$) and with the lithium salt of the 5-pyrazole derivative (compound (IV) with $(X, Y) = (\text{NR}_4, N)$), according to the scheme below. Such
 15 syntheses are described in particular in: Ramacciotti, Alessio; Fiaschi, Rita; Napolitano, Elio; *Tetrahedron asymmetry*; 1996; 1101-1104:



In the case where the compound of formula (II)
 20 corresponds to formula (IIb) below in which R_1 , R_2 , R_3 ,

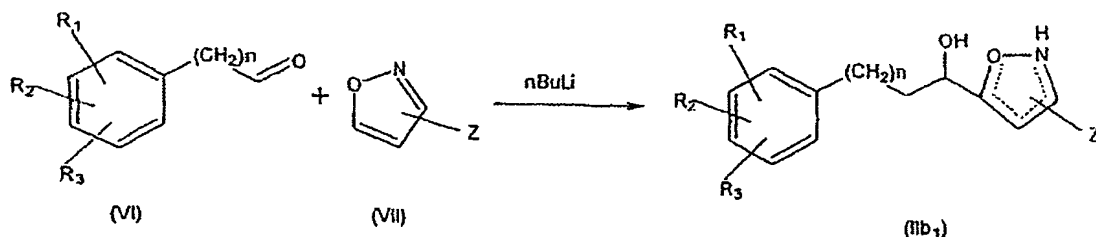
X, Y and Z have the same definition as in formula (I):



(IIb)

the product (IIb) is advantageously prepared by a method characterized in that:

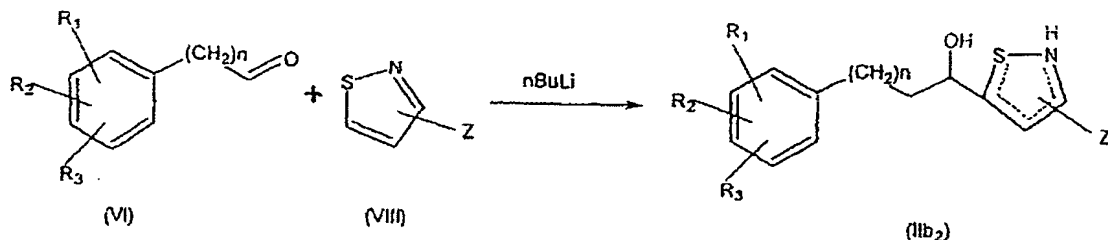
- 5 in the case where X = O and Y = N, the aldehyde (VI) is reacted with a lithium salt of the heterocycle (VII):



- 10 In the case where (X, Y) represents the pair of atoms (NR₄, N), R₄ being as defined above, the procedure is essentially carried out according to the scheme above using the method of protection described by Katritzky et al.: Alan R. Katritzky, Ping Lue and Kunihiro Akutagawa, *Tetrahedron* **45**, 13 (1989), 4253-
15 4262. The NH functional group of the pyrazole ring is protected with formaldehyde in order to avoid an N-alkylation. The resulting N-protected pyrazole is treated with n-butyllithium to give the lithium salt which, in the presence of aldehyde (VI), makes it
20 possible to obtain the products of formula (IIb).

- When X = S and Y = N, the product (IIb) is obtained according to the methods described in the following articles: A.J. Layton and E. Lunt J. Chem. Soc. C 1968, 611-614 and Ashton, Michael J and al. J. Med. Chem., 27, 10, 1984, 1245-1253. The isothiazole

(VIII) is treated with n-butyllithium to give the lithium salt which in the presence of aldehyde (VI) makes it possible to obtain a 5-alkylation so as to correspond to the products of formula (IIb₂).



5

Advantageously, according to the invention, the methods above apply to the case where $n = 0$.

Advantageously, according to the invention, the treatment of the product (II) in a basic alcoholic medium is characterized in that the alcohol in which the dehydration and the crystallization occur is ethanol, methanol or isopropyl alcohol. Advantageously still, the base which is added to the alcohol is sodium hydroxide in the form of an aqueous solution.

15 Preferably, the aqueous sodium hydroxide solution is a solution having a concentration of between 0.1M and 5M, advantageously between 0.5M and 4M, still more advantageously between 1M and 3M.

Preferably, the method comprises the following steps: dissolution of the product (II) in alcohol under reflux; addition of the base until the compound (I) precipitates; addition of alcohol, still under reflux, until the precipitate is solubilized; cooling of the solution which causes crystallization of (I);

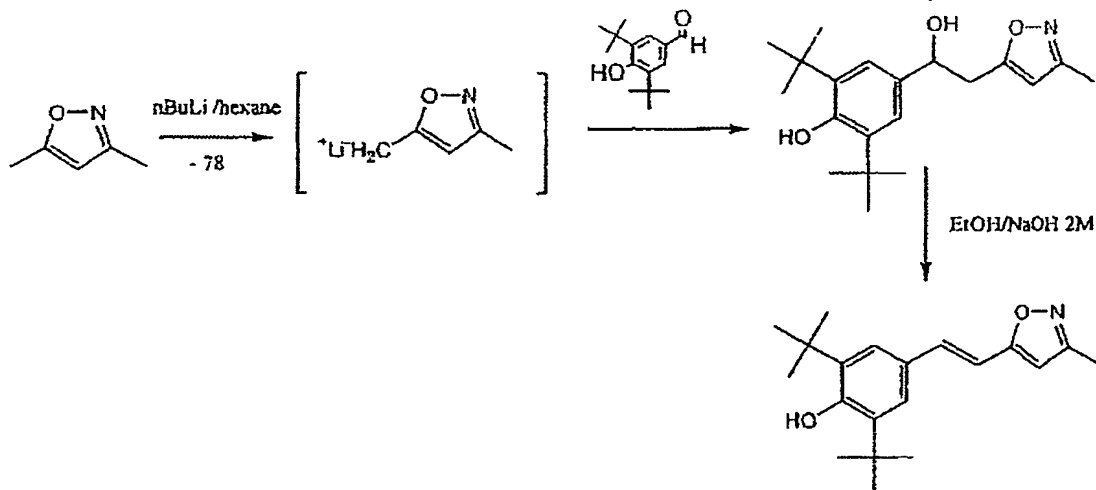
20 filtration and washing of the crystals.

25

EXAMPLES

I Synthesis of (E)-5-[2-(3,5-di-tert-butyl-4-hydroxyphenyl)vinyl]-3-methylisoxazole

1.1 Reaction scheme:



5

1.2 Reagents

The quantities of reagent are presented in table 1 below

10 **Table 1**

Reagents	MW g/mol	Eq.	mmol	Quantity
3,5-dimethylisoxazole	7.12 (d=0.99)	2.1	257.13	25 g
n-butyllithium in hexane	2.5M	2.1	257.413	100 ml
3,5-di-tert-butyl-4-hydroxybenzaldehyde	234.34		122.577	28.724 g
THF			450 ml	

1.3 Procedure:

n-Butyllithium (100 ml) is added (over 45 minutes) dropwise to a solution of 3,5-dimethylisoxazole (25 g) in THF (200 ml) cooled to -78°C. After stirring for 1 hour at -78°C, 3,5-di-tert-butyl-4-hydroxybenzaldehyde (27.724 g) in solution in THF (250 ml) is added dropwise over 3 hours. At the end of the addition, the reaction mixture is left for

20

2 h 30 min with stirring at -78°C.

The progress of the reaction is monitored by thin-layer chromatography:

Hexane/AcOEt	Rf aldehyde	Rf product (I)	Rf product (II)
90/10	0.53	0.4	0.06
80/20		0.6	0.21

5

When the aldehyde has been consumed, the following treatment is carried out:

- concentration of the solvents (THF/hexane) by evaporation under vacuum,
- 10 - taking up of the medium in 200 ml of ethyl acetate,
- washing with twice 100 ml H₂O (pH aqueous phase 7),
- concentration under vacuum.

The second part of the method in accordance with the invention comprises the following steps:

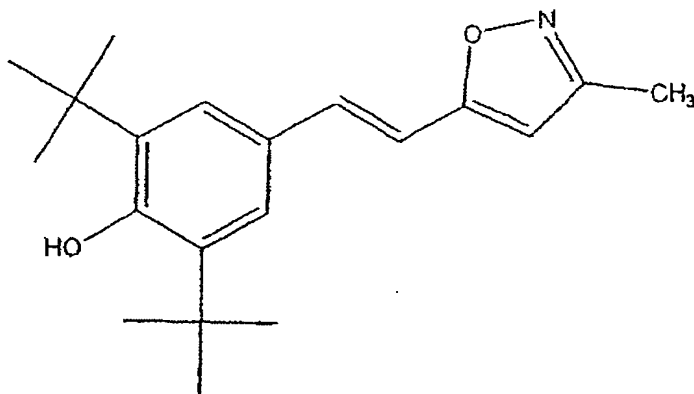
- 15 a) Recrystallization/dehydration EtOH/NaOH 2M
 - addition of 100 ml of ethanol, the mixture is heated under reflux
 - addition of 2M NaOH until the product (I) precipitates (about 100 ml)
 - 20 - addition of ethanol until solubilization of (I) is obtained
 - filtration and washing of the crystals with 100 ml of H₂O and 100 ml of hexane.
- (E)-5-[2-(3,5-Di-tert-butyl-4-hydroxyphenyl)vinyl]-3-methylisoxazole is obtained with an overall yield relative to the starting material which varies between 50% and 86%.

- b) Optionally, a recrystallization with EtOH (8 ml/g) is then carried out
- 30 Mass obtained: 23.2 g/overall yield: 58%

II - Analysis of (E)-5-[2-(3,5-di-tert-butyl-4-hydroxyphenyl)vinyl]-3-methylisoxazole

2.1 Structural study

- Structural formula of (E)-5-[2-(3,5-di-tert-butyl-4-hydroxyphenyl)vinyl]-3-methylisoxazole:
- 35



2.1.1 Infrared spectrum

The infrared spectrum is performed between 4000 and 400 cm^{-1} on a KBr pellet containing about 1% of (E)-5-[2-(3,5-di-tert-butyl-4-hydroxyphenyl)vinyl]-3-methylisoxazole

The principal peaks observed are:

3500 cm^{-1} : $\nu_{\text{O-H}}$

2850-2950 cm^{-1} : $\nu_{\text{C-H}}$ (tBu, CH_3 , CH)

1640, 1570 and 1440 cm^{-1} : $\nu_{\text{C=C}}$ and $\nu_{\text{C=N}}$

1230 and 1100 cm^{-1} : $\nu_{\text{C-O}}$

960 cm^{-1} : $\nu_{\text{N-O}}$

The IR spectrum is in conformity with the expected structure.

2.1.2 NMR spectrum

The ^1H NMR spectrum is performed on a solution in deuterated chloroform with a 200 MHz spectrometer.

Solvent peaks: TMS: 0 ppm; H_2O : 1.55 ppm; CHCl_3 : 7.24 ppm.

The peaks for the compound are analyzed in table 2 below:

Table 2:

Chemical shift	Multiplicity	Integration	Attribution
1.45 ppm	singlet	18 H	2 tBu
2.3 ppm	singlet	3 H	CH ₃ at the 6-position
5.4 ppm	singlet	1 H	OH
6.0 ppm	singlet	1 H	H ₅
6.75 ppm	doublet	1 H	H ₄ with J H ₃ -H ₄ = 16 Hz
7.2 ppm	doublet	1 H	H ₃
7.3 ppm	singlet	2 H	H ₁ and H ₂

The NMR spectrum is in conformity with the expected structure.

5 2.1.3 Mass spectrum

The mass spectrum is performed in "FAB positive" ionization with NBA (3-nitrobenzyl alcohol) for matrix.

The following ions are observed (table 3):

10 **Table 3**

m/z	Attribution
313	M ⁺
314	(M + H) ⁺
627	(2 M + H) ⁺

The mass spectrum is in conformity with the expected structure.

2.1 Identification

15 2.2.1 Melting point

The melting point was measured on various batches, the results are summarized in table 4 below:

Table 4

Batch No.	Appearance	Melting point	Purity
MC00III17	White grains	189°C	99.5%
DG00IV53	White crystals	191°C	100.7%
DG00IV42	White crystals	189°C	100.7%
DG00IV52	Yellow-white flakes	190°C	99.8%
MC00III11	Yellow-white grains	186°C	97.6%
MC99II159	Yellow-white grains	189°C	100.3%
DG01V21	Beige-yellow grains	188°C	97.4%
DG01V20.3	Beige-yellow crystals	191°C	96.7%
DG01V20.2	Pink grains	187°C	91.2%

It is observed that the melting point of (E)-5-[2-(3,5-di-tert-butyl-4-hydroxyphenyl)vinyl]-3-methylisoxazole is in the range of 185-193°C.

Apart from batch DG01V20.2, all the batches have a purity greater than 95% regardless of the appearance of the powder.

2.2.2 TLC

The TLC analysis is carried out under the following conditions:

- F₂₅₄ silica plate
- sample: 100 µl of solution at 0.4 mg/ml in MeOH
- control at 1%: 20 µl of solution at 0.02 mg/ml
- control at 5%: 100 µl of solution at 0.02 mg/ml
- focusing: MeOH
- elution: hexane 90/10 ethyl acetate
- migration: about 5 cm
- development: UV 254 nm and solution at 5% FeCl₃ in 0.5M HCl (EtOH at 95%)
- results:

X 254 nm: (E)-5-[2-(3,5-di-tert-butyl-4-hydroxyphenyl)vinyl]-3-methylisoxazole has a spot of high intensity at R_f: 0.30. The product of degradation

also has a spot at Rf: 0.34.

X Developing agent FeCl₃: An orange-brown spot is obtained for (E)-5-[2-(3,5-di-tert-butyl-4-hydroxyphenyl)vinyl]-3-methylisoxazole at the same Rf on an orange-colored background for the plate.

2.2 Assay

2.3.1 Loss on drying

The loss on drying makes it possible to determine the content of water and of organic solvent. It is determined on 1 g if possible in an oven at 100-105°C for 3 h or until constant weight is obtained.

A weighed sample of the order of 1 g is introduced into a previously dried crystallizing dish, and then the latter is placed in an oven thermostated at 100-105°C for 3 h. The crystallizing dish is allowed to cool in a desiccator to room temperature. The crystallizing dish is weighed and the loss is calculated as % by the following formula:

$$\text{Loss (\%)} = \frac{(W - m) \times 100}{W}$$

with W: weighed amount introduced
m: mass after heating in an oven

2.3.2 HPLC assay

Principle:

The isocratic HPLC technique allows the assay of (E)-5-[2-(3,5-di-tert-butyl-4-hydroxyphenyl)vinyl]-3-methylisoxazole under conditions of specificity in relation to the two synthesis precursors, to an unknown synthesis impurity and to the product of degradation by UV radiation.

Method:

The purity of (E)-5-[2-(3,5-di-tert-butyl-4-hydroxyphenyl)vinyl]-3-methylisoxazole is determined by isocratic HPLC by external calibration and expressed relative to the dry substance.

Procedure:

Materials:

Column: Lichrosphere C18, 5 μ m, 100 Å,
125 × 4 mm + precolumn (4 × 4 mm)

5 Mobile phase: 250 H₂O + 750 MeOH (HPLC
solvents)

Flow rate: 1 ml/min

Room temperature

Detector: 240 nm

10 Volume for injection: 25 μ l

Integrator: ST = 25 min, CS = 2.5, SP = 400,
Noise = 2, Sens = 40, Att = 4

Merck chain: L-6200A type pump

Injector AS-2000A type

15 Detector L-4250 type

Integrator D-2500 type

The (E)-5-[2-(3,5-di-tert-butyl-4-hydroxyphenyl)-
vinyl]-3-methylisoxazole control was synthesized,
purified and dried in the laboratory.

20 Results:

The HPLC analysis makes it possible to verify
that the purity of the product obtained by the method
according to the invention is greater than 98%.